AHOT Acta Haematologica Oncologica Turcica

Acta Haematol Oncol Turc

Original Article

DOI: 10.4274/ahot.galenos.2026.2026-2-7

The Effect of Nutritional Support on Malnutrition and Muscle Loss in Hematological Cancer Patients: A Retrospective Single-center Study

Ahmet Sarıcı[1], Mehmet Ali Erkurt[1], Emin Kaya[1], İrfan Kuku[1], İlhami Berber[1], Süleyman Arslan[1], Birgül Deniz[1], İpek Balıkçı Çiçek[2], Emine Hidayet[1]

[1]İnönü University, Turgut Özal Medical Center, Department of Adult Hematology, Malatya, Türkiye
[2]İnönü University Faculty of Medicine, Department of Biostatistics and Medical Informatics, Malatya, Türkiye

ABSTRACT

Aim: Malnutrition is frequently observed in patients with hematopoietic malignancies due to the effects of the primary disease and treatments. The aim of this study is to assess the nutritional status of patients who have undergone hematopoietic stem cell transplantation and to evaluate the effects of malnutrition on anthropometric measurements, muscle function, and skinfold thickness.

Methods: This retrospective study included 37 patients with hematological malignancies who were at risk of malnutrition and sarcopenia, as determined using the NRS2002. The nutritional status of the patients was evaluated before and after nutritional support using the Global Leadership Initiative on Malnutrition (GLIM) criteria. Additionally, triceps, calf, suprailiac, and subscapular skinfold thicknesses, as well as handgrip strength (HG), were measured before and after nutritional support. The patients' malnutrition universal screening tool (MUST) scores, sarcopenia levels, body mass index (BMI), and weight changes were compared before and after nutritional support.

Results: The participants' weight and BMI showed statistically significant changes after nutritional therapy. The median weight increased from 59 (38-88) kg to 61 (42-87) kg, and the median BMI rose from 21.75 (15.3-28.4) to 23 (16.8-28.2) ($p<0.001$). The MUST score, sarcopenia risk, skinfold thickness, and HG measurements showed significant decreases (all $p<0.001$). Increases in weight, BMI, hand-grip strength, and skinfold thickness measurements, and decreases in MUST score and sarcopenia risk were observed. The mean survival time was calculated as 10.89 months. The 6-month survival rate was 89.2%.

Conclusion: Providing nutritional support according to the GLIM criteria to patients with hematological malignancies can help protect them from sarcopenia.

Keywords: Malnutrition, hematologic malignancy, sarcopenia, NRS2002, MUST score

Introduction

Malnutrition is prevalent in patients with hematologic cancers and results from both the presence of the tumor and the medical treatments they undergo. This condition has a detrimental impact on patients' quality of life and on treatment-related toxicities. As a result, nutrition plays a crucial role in the care of hematologic cancer patients [1-3].

Nutritional status plays a critical role in the treatment of hemato-oncological patients. It is considered a valuable tool in the selection and process of treatment in hemato-oncology patients [4]. It is well-established that the metabolism and nutrition of patients with hematological malignancies are adversely affected by both their underlying diseases and the treatments they undergo [4]. Research has demonstrated that nutritional deficiencies can negatively impact the treatment outcomes of these patients [5].

The European Society for Clinical Nutrition and Metabolism (ESPEN) has issued guidelines recommending the periodic evaluation of nutritional intake, weight changes, and body

Address for Correspondence: Ahmet Sarıcı MD, İnönü University, Turgut Özal Medical Center, Department of Adult Hematology, Malatya, Türkiye
E-mail: ahmetsarici44@gmail.com **ORCID ID:** orcid.org/0000-0002-5916-0119
Received: 27.02.2026 **Accepted:** 28.03.2026 **Epub:** 02.04.2026

Cite this article as: Sarıcı A, Erkurt MA, Kaya E, et al. The effect of nutritional support on malnutrition and muscle loss in hematological cancer patients: a retrospective single-center study. Acta Haematol Oncol Turc. [Epub Ahead of Print]

mass index (BMI) should be regularly performed at the time of diagnosis and subsequent follow-ups to identify malnutrition [2].

Sarcopenia characterized by progressive and pervasive skeletal muscle disorder is confirmed by the presence of low muscle mass or quality [6]. All patients with hemato-oncological diagnoses should be screened for malnutrition and sarcopenia before and during treatment [7,8]. Patients at risk of sarcopenia should be carefully assessed for muscle mass, muscle strength and function [9]. Medical nutrition treatments for patients with malnutrition and sarcopenia should be carefully planned [10,11].

The Global Leadership Initiative on Malnutrition (GLIM) framework recommends a two-stage process for the diagnosis of malnutrition in adults: initially, risk is identified using a validated nutritional screening instrument; this is followed by a comprehensive assessment which requires the presence of at least one phenotypic indicator (such as unintentional weight loss, a low BMI, or reduced muscle mass) and at least one etiologic factor (such as inadequate dietary intake or absorption, or an underlying inflammatory condition or disease burden) to establish the diagnosis. Phenotypic measures are used to determine the severity of malnutrition. This model aims to harmonize the global definition of malnutrition and facilitate its consistent implementation in clinical settings [12].

There are limited data on functional and anthropometric changes after structured nutritional support in hematopoietic stem cell transplantation (HSCT) patients diagnosed using GLIM criteria. This study aimed to assess the nutritional status of patients with hematological malignancies who underwent HSCT and to explore the impact of malnutrition on anthropometric measurements, muscle function, and skinfold thickness.

Methods

Approval for conducting the study was obtained from the İnönü University Faculty of Health Sciences Non-Interventional Clinical Research Ethics Committee (approval no: 2024/6234, date: 16.07.2024). Patient data were collected retrospectively. Patients who underwent HSCT in our bone marrow transplantation unit were included in the study. This study was conducted in accordance with the principles of the Declaration of Helsinki.

The primary outcome of the study was the change in handgrip strength (kg) following structured nutritional support. Secondary outcomes included changes in BMI, weight, skinfold thickness, malnutrition universal screening tool (MUST) score, and sarcopenia risk. This study included 37 patients diagnosed with hematological malignancies who were deemed to be at risk of malnutrition and sarcopenia, determined using the NRS2002 [12]. The nutritional status of the patients was evaluated before and after nutritional support using GLIM criteria [13].

According to ESPEN guidelines, high-energy oral nutritional supplementation (ONS) was typically initiated at 1-2 bottles per day (300-600 kcal) and increased to 600-900 kcal/day depending on the patient's requirements and tolerance. The aim of oral nutritional support was to meet the patient's total energy needs of 25-30 kcal/kg/day and protein requirements of 1.2-1.5 g/kg/day. Intake, gastrointestinal tolerance, and weight were monitored regularly, and supplementation was continued until the nutritional targets were achieved.

Sarcopenia risk was assessed according to the NRS-2002 criteria. Values prior to nutritional support and at six months thereafter were compared. Triceps, calf, suprailiac, and subscapular skinfold thicknesses (triceps skinfold thickness, calf skinfold thickness, suprailiac skinfold thickness, subscapular skinfold thickness) and handgrip strength (HG) were recorded before and after nutritional support. The patients' MUST scores [14], sarcopenia levels, BMI, and weight changes were compared before and after six months of nutritional support.

Additionally, the survival analysis aimed to determine whether there was a difference between the groups that received nutritional support and those that did not.

Study Population

Inclusion criteria: Patients were eligible if they: were ≥18 years old, had a confirmed diagnosis of hematological malignancy, underwent autologous or allogeneic HSCT (allo-HSCT), were identified as being at risk of malnutrition using NRS-2002, received structured nutritional support during hospitalization.

Exclusion criteria: Severe organ failure preventing anthropometric evaluation, neuromuscular disorders affecting handgrip measurement, incomplete medical records, a total of 37 patients met the inclusion criteria.

Structured Nutritional Support Protocol

All patients received individualized, structured nutritional support which was supervised by a clinical nutrition team and initiated within the first 48 hours of hospitalization for HSCT.

The nutritional intervention included the following: energy targets of 25-30 kcal/kg/day, adjusted based on clinical condition and metabolic demand; protein targets of 1.2-1.5 g/kg/day, increased up to 1.5-2.0 g/kg/day in patients with severe catabolism; and ONS containing.

Nutritional support, including whey protein, essential amino acids, vitamins, and trace elements, was maintained throughout the hospitalization period (median duration: 180 days).

Statistical Analysis

Categorical variables in the study were summarized using frequencies (percentages). The normality of the quantitative data distribution was evaluated using the Shapiro-Wilk test. For quantitative data that did not show a normal distribution, the median (minimum-maximum) was used for summarization, while quantitative data that showed a normal distribution were summarized using mean ± standard deviation. In statistical analyses, two dependent quantitative variables were analyzed using either the dependent samples t-test or the Wilcoxon signed-rank test, depending on the normality

of the distribution. The relationship between variables was examined using the Spearman's rho correlation coefficient. A p value <0.05 was considered statistically significant in the statistical analyses. All analyses were performed using IBM SPSS Statistics 26.0 for Windows (New York, USA). Survival curves were visualized using Python (version 3.13.5) with the lifelines library (version 0.30.3).

Results

The median age of the patients included in the study was 56. Twenty-five (67.57%) of the patients were male, and 12 (32.43%) were female. The patients' demographic data are presented in Table 1.

As illustrated in Table 2, a comprehensive statistical analysis was conducted to assess changes in weight, muscle strength, and body fat measurements among all patients (p1), male patients (p2), and female patients (p3). The analysis showed statistically significant increases in weight and BMI over time. The median weight increased from 59 (38-88) kg to 61 (42-87) kg (p=0.001), and the median BMI increased from 21.75 (15.3-28.4) to 23 (16.8-28.2) (p<0.001).

A significant decrease was observed in the MUST score which decreased from 4 (0-6) to 2 (0-5) (p<0.001). Similarly, the risk of sarcopenia significantly decreasedreducing from 4 (1-9) to 2 (0-7) (p<0.001). In addition, a notable increase in arm muscle strength was observed. Specifically right arm strength increased from 18±9 kg to 22±9 kg (p<0.001), while left arm strength increased from 18±9 kg to 22±9 kg (p<0.001). Increases were also observed in the skinfold thickness measurements, indicating changes in body fat distribution: suprailiac skinfold thickness increased from 10 (2-22) mm to 11 (7-25) mm (p<0.001), triceps skinfold thickness increased from 12 (3-32) mm to 14 (2-33) mm (p<0.001), and subscapular skinfold thickness increased from 12 (3-25) mm to 13 (6-25) mm (p=0.002). These findings suggest that there were significant improvements in the participants' physical condition over time, with increases, particularly in weight, BMI, arm strength, and skinfold thickness, while the MUST score and sarcopenia risk decreased.

Table 1. Descriptive statistics table of demographic variables

		Mean ± SD	Median (min-max)
Age		53±18	56 (20-83)
Weight (before)		60±10	59 (38-88)
Weight (after)		62±9	61 (42-87)
Height		165±10	170 (145-180)
BMI (before)		21±3	21.75 (15.3-28.4)
BMI (after)		22±3	23 (16.8-28.2)
		Number	**Percentage (%)**
Gender	**Male**	25	67.57
	Female	12	32.43
Primary disease	**HL**	2	6
	Non-HL	1	3
	AML	4	10
	ALL	4	10
	CML	1	3
	MM	25	68
HSCT	**Autologuous**	14	38
	Allogeneic	23	62

SD: Standard deviation, min: Minimum, max: Maximum, HL: Hodgkin lymphoma, AML: Acute myeloid leucemia, ALL: Acute lymphoblastic leukemia, CML: Chronic myeloid leukemia, MM: Multiple myeloma, HSCT: Hematopoietic stem cell transplantation, BMI: Body mass index

In this study, changes in weight, muscle strength, and body fat distribution were analyzed separately for male and female patients. In male patients, weight exhibited a significant increase; the average weight rose from 63±10 kg to 66±8 kg (p<0.001). The BMI of male patients also exhibited a statistically significant increase, from 20.4 (15.6-28.4) to 21.38 (17.2-28.2) (p=0.001). The MUST score decreased significantly from 4 (0-6) to 2 (0-5) (p<0.001). Furthermore, the risk of sarcopenia also significantly decreased in men, dropping from 4.7±2 to 2±1 (p<0.001). Right arm muscle strength increased from 19±10 kg to 24±10 kg (p<0.001), while left arm muscle strength increased from 19±10 kg to 24±9 kg (p<0.001). Significant increases were also observed in suprailiac, triceps, and subscapular skinfold thicknesses in men: suprailiac increased from 11 (2-22) mm to 11 (7-25) mm (p=0.001), triceps increased from 10 (3-32) mm to 12 (2-33) mm (p=0.001), and subscapular increased from 11 (3-25) mm to 11 (6-25) mm (p=0.015).

In female patients, weight increase was not statistically significant; the average weight increased from 52±6 kg to 53±6 kg, but this increase was not significant (p=0.338). Women's BMI increased from 23 (15.3-25.68) to 24 (16.8-26.63); this increase was statistically significant (p=0.034). The MUST score also significantly decreased in women, dropping from 4 (2-5) to 2 (0-4) (p=0.007). The risk of sarcopenia significantly decreased in women as well, from 4±2 to 2±2 (p<0.001). Right arm muscle strength increased from 16±7 kg to 19±7 kg (p=0.004), and left arm muscle strength increased from 14±7 kg to 19±7 kg (p=0.003). Among women, suprailiac skinfold thickness changed from 10 (4-20) mm to 10 (8-20) mm; this change was not statistically significant (p=0.054). Triceps skinfold thickness increased from 19 (8-25) mm to 21 (10-30) mm (p=0.005). Subscapular skinfold thickness in women increased from 14.5 (8-25) mm to 18 (7-25) mm, and this increase was statistically significant (p=0.049).

These findings suggest that in men weight, BMI, muscle strength, and skinfold thicknesses showed statistically significant increases, whereas in women BMI, muscle strength, and certain skinfold thicknesses showed statistically significant increases; weight change was not significant.

Table 3 shows correlations between the pre-nutrition measurements of the variables. According to the findings in Table 3, a robust positive correlation was found between BMI and weight (r=0.667, p<0.001), while a negative correlation was observed between the MUST score and BMI (r=-0.694, p<0.001). Additionally, a positive relationship was identified

Table 2. Analysis table of changes in weight, muscle strength, and body fat measurements

Variables		p1	Male	p2	Female	p3
Weight (before)	59 (38-88)	0.001*	63±10	<0.001**	52±6	0.338**
Weight (after)	61 (42-87)		66±8		53±6	
BMI (before)	21 (15-28)	<0.001*	20 (15-28)	0.001*	22 (15-25)	0.034*
BMI (after)	23 (16-28)		21 (17-28)		24 (16-26)	
MUST score (before)	4 (0-6)	<0.001*	4 (0-6)	<0.001*	4 (2-5)	0.007*
MUST score (after)	2 (0-5)		2 (0-5)		2 (0-4)	
Sarcopenia risk (before)	4 (1-9)	<0.001*	4±2	<0.001**	4±2	<0.001**
Sarcopenia risk (after)	2 (0-7)		2±1		2±2	
Right arm strength (before)	18±9	<0.001**	19±10	<0.001**	16±7	0.004**
Right arm strength (after)	22±9		24±9		19±7	
Left arm strength (before)	18±9	<0.001**	19±10	<0.001**	14±7	0.003**
Left arm strength (after)	22±9		24±9		18±7	
Suprailiac skinfold (before)	10 (2-22)	<0.001*	11 (2-22)	0.001*	10 (4-20)	0.054*
Suprailiac skinfold (after)	11 (7-25)		11 (7-25)		10 (8-20)	
Triceps skinfold (before)	12 (3-32)	<0.001*	10 (3-32)	0.001*	19 (8-25)	0.005*
Triceps skinfold (after)	14 (2-33)		12 (2-33)		21 (10-30)	
Suprascapular skinfold (before)	12 (3-25)	0.002*	11 (3-25)	0.015*	14.5 (8-25)	0.049*
Suprascapular skinfold (after)	13 (6-25)		11 (6-25)		18 (7-25)	
Calf skinfold (before)	13 (3-39)	0.003*	12 (3-35)	0.012*	20 (6-39)	0.101*
Calf skinfold (after)	14 (7-40)		12 (8-36)		21.5 (7-40)	

Variables are presented as mean ± standard deviation or median (minimum-maximum) based on the normality of the distribution. p1: significance test result for measurements between all patients; p2: significance test result for measurements between male patients; p3: significance test result for measurements between female patients; *: Wilcoxon test; **: Paired sample t-test
BMI: Body mass index, MUST: Malnutrition universal screening tool

between the MUST score and sarcopenia risk (r=0.334, p=0.043). A negative relationship was found between right arm strength and sarcopenia risk (r=-0.482, p=0.003). Similarly, a negative correlation was observed between left-arm strength and sarcopenia risk (r=-0.518, p=0.001). Strong positive relationships were found between subscapular skinfold thickness and BMI (r=0.712, p<0.001), and between subscapular and triceps skinfold thickness (r=0.575, p<0.001). Furthermore, positive relationships were identified between calf skinfold thickness and triceps skinfold thickness (r=0.736, p<0.001), and between calf and subscapular skinfold thickness (r=0.762, p<0.001). These findings suggest significant relationships among increased sarcopenia risk, decreased muscle strength, and body fat thickness. A positive relationship was found between suprailiac skinfold thickness and BMI (r=0.409, p=0.012). Additionally, a positive relationship was found between triceps skinfold thickness and BMI (r=0.384, p=0.019). Conversely, a negative relationship was identified between subscapular skinfold thickness and sarcopenia risk (r=-0.451, p=0.005). These results suggest that an elevated risk of sarcopenia may be associated with increased body fat thickness.

Table 4 shows the correlations among the post-nutrition measurements. According to the table, a positive relationship was found between BMI and weight (r=0.486, p=0.002), while a negative relationship was observed between BMI and MUST score (r=-0.454, p=0.005). A positive correlation was also found between sarcopenia risk and the MUST score (r=0.467, p=0.004), whereas a negative correlation was found between sarcopenia risk and left arm strength (r=-0.416, p=0.010). A strong positive relationship was found between subscapular skinfold thickness and BMI (r=0.662, p<0.001), whereas triceps skinfold thickness was negatively associated with sarcopenia risk (r=-0.486, p=0.002). Additionally, positive correlations were found between calf skinfold thickness and both triceps skinfold thickness (r=0.734, p<0.001) and subscapular skinfold thickness (r=0.717, p<0.001). Positive relationships were also found between suprailiac skinfold thickness and BMI (r=0.346, p=0.036) and between triceps skinfold thickness and BMI (r=0.374, p=0.023). These findings highlight the effects of post-nutritional measurements on sarcopenia risk on and muscle strength. The significant relationships between BMI, sarcopenia risk, and muscle strength are important to consider in nutritional interventions and monitoring.

According to the Kaplan-Meier survival analysis, a total of 37 patients were included in the study: 4 patients (10.81%) experienced death, and 33 patients (89.19%) survived. The mean survival time was 10.89 months [standard error (SE): 0.524, 95% confidence interval (CI): 9.87-11.92 months]. The survival curve showed a gradual decline during the first 3 months, reaching approximately 89% by the 3rd month, and then remained stable at this level over the following 12

Table 3. Correlation table of pre-nutrition measurements of variables

Variables		Weight (before)	BMI	MUST score (before)	Sarcopenia risk (before)	Right arm strength (before)	Left arm strength (before)	Suprailiac skinfold (before)	Triceps skinfold (before)	Subscapular skinfold (before)	Calf skinfold (before)
Weight (before)	**r**	1.000									
	p	-									
BMI (before)	**r**	0.667**	1.000								
	p	**<0.001**	-								
MUST score (before)	**r**	-0.384*	-0.694**	1.000							
	p	**0.019**	**<0.001**	-							
Sarcopenia risk (before)	**r**	-0.164	-0.177	0.334*	1.000						
	p	0.332	0.295	**0.043**	-						
Right arm strength (before)	**r**	0.169	0.154	-0.231	-0.482**	1.000					
	p	0.319	0.364	0.168	**0.003**	-					
Left arm strength (before)	**r**	0.267	0.074	-0.197	-0.518**	0.874**	1.000				
	p	0.109	0.665	0.243	**0.001**	**<0.001**	-				
Suprailiac skinfold (before)	**r**	0.319	0.409*	-0.142	-0.114	0.197	0.196	1.000			
	p	0.054	**0.012**	0.402	0.501	0.242	0.244	-			
Triceps skinfold (before)	**r**	0.066	0.384*	-0.293	-0.129	0.084	-0.036	0.529**	1.000		
	p	0.698	**0.019**	0.079	0.447	0.623	0.835	**0.001**	-		
Suprascapular skinfold	**r**	0.428**	0.712**	-0.451**	0.010	0.021	-0.056	0.575**	0.564**	1.000	
	p	**0.008**	**<0.001**	**0.005**	0.955	0.902	0.741	**<0.001**	**<0.001**	-	
Calf skinfold (before)	**r**	0.209	0.526**	-0.331*	-0.225	-0.005	-0.159	0.489**	0.741**	0.762**	1.000
	p	0.215	**0.001**	0.045	0.181	0.977	0.348	**0.002**	**<0.001**	**<0.001**	-

r: Spearman's rho correlation coefficient, *: p<0.05, **: p<0.001, bolded values indicate statistical significance
BMI: Body mass index, MUST: Malnutrition universal screening tool

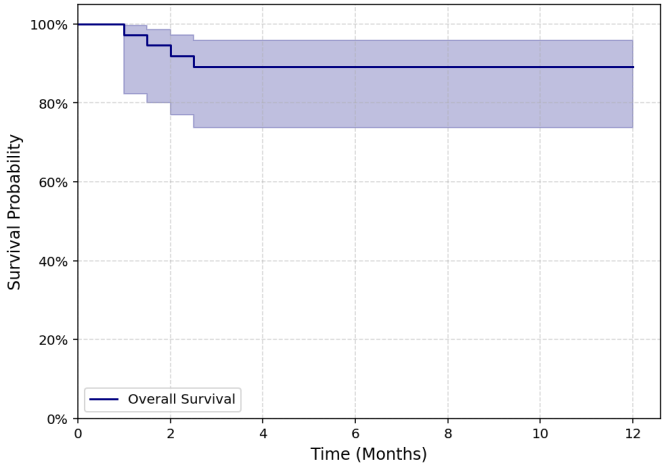

Figure 1. Survival outcomes of hematologic malignancy patients with weight loss

months. Thus, the 6-month survival rate was 89.2% (Figure 1, Table 5).

The mean survival time for male patients was 10.24 months (SE: 0.516; 95% CI: 9.228-11.252), while for female patients it was 10.33 months (SE: 1.077; 95% CI: 8.222-12.445). The log-rank test showed no statistically significant difference between the survival curves (p=0.45) (Figure 2, Table 6).

Discussion

There is limited information in the literature regarding sarcopenia and nutritional deficiencies in patients with hematological malignancies. Cachexia and sarcopenia are thought to play a significant role in the treatment process in this patient population. In addition to necessity of primary malignancy treatments, supportive treatments for cachexia and sarcopenia are well understood [8].

In the HSCT setting, patients are frequently exposed to profound metabolic stress, systemic inflammation, mucosal toxicity, and reduced nutritional intake, all of which predispose them to progressive weight loss and muscle wasting. In this context, the prevention of further decline may be clinically meaningful. Therefore, the observed median weight increase from 59 kg to 61 kg, although modest in absolute terms, may represent stabilization of nutritional status in a population typically at risk of ongoing catabolic deterioration rather than simple weight gain.

Importantly, minimal clinically important differences (MCID) for anthropometric parameters and HG have not been clearly established in HSCT populations. As a result, while the observed changes reached statistical significance and were directionally consistent with improved functional status, their precise clinical magnitude remains uncertain. These findings should therefore be interpreted cautiously, and larger prospective

Table 4. Correlation table of post-nutrition measurements of variables

Variables		Weight (after)	BMI (after)	MUST score (after)	Sarcopenia risk (after)	Right arm strength (after)	Left arm strength (after)	Suprailiac skinfold (after)	Triceps skinfold (after)	Suprascapular skinfold (after)	Calf skinfold (after)
Weight (after)	r	1.000									
	p	-									
BMI (after)	r	0.486**	1.000								
	p	**0.002**	-								
MUST score (after)	r	-0.151	-0.454**	1.000							
	p	0.372	**0.005**	-							
Sarcopenia risk (after)	r	0.040	0.075	0.467**	1.000						
	p	0.813	0.657	**0.004**	-						
Right arm strength (after)	r	0.283	0.096	-0.239	-0.313	1.000					
	p	0.090	0.570	0.155	0.059	-					
Left arm strength (after)	r	0.289	0.040	-0.276	-0.416*	0.907**	1.000				
	p	0.083	0.812	0.098	**0.010**	**<0.001**	-				
Suprailiac skinfold (after)	r	0.237	0.346*	-0.227	0.095	0.199	0.154	1.000			
	p	0.157	**0.036**	0.177	0.574	0.239	0.363	-			
Triceps skinfold (after)	r	-0.041	0.374*	-0.486**	0.061	0.053	-0.024	0.427**	1.000		
	p	0.807	0.023	**0.002**	0.720	0.758	0.890	**0.008**	-		
Suprascapular skinfold (after)	r	0.201	0.662**	-0.365*	0.244	0.125	0.098	0.453**	0.599**	1.000	
	p	0.232	**<0.001**	**0.026**	0.146	0.462	0.563	**0.005**	**<0.001**	-	
Calf skinfold (after)	r	-0.054	0.456**	-0.409*	0.044	0.090	-0.035	0.341*	0.734**	0.717**	1.000
	P	0.751	**0.005**	**0.012**	0.797	0.596	0.839	**0.039**	**<0.001**	**<0.001**	-

r: Spearman's rho correlation coefficient, *: p<0.05, **: p<0.001, bolded values indicate statistical significance
BMI: Body mass index, MUST: Malnutrition universal screening tool

Table 5. Mean survival time of hematologic cancer patients with weight loss

Mean survival time	Standard error	95% CI
10.892	0.524	9.865 to 11.919
CI: Confidence interval		

Table 6. The effect of gender on survival time in hematologic cancer patients with weight loss

Factor	Mean survival time	Standard error (SE)	95% CI
Male	10.2	0.5	9.2 to 11.2
Female	10.3	1	8.2 to 12.4
CI: Confidence interval			

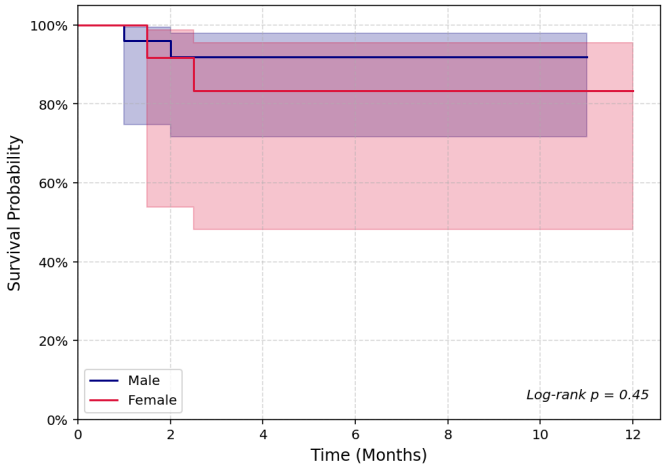

Figure 2. Effect of gender on survival time in hematologic cancer patients with weight loss

studies are required to define clinically meaningful thresholds for nutritional and func-tional recovery in this high-risk group.

The presence of cachexia and sarcopenia has been reported in patients with hematological malignancies, as well as in solid tumors [15]. A comprehensive review of the extant literature, encompassing 5,687 patients diagnosed with hematologic malignancies examined a total of 29 studies, the majority of which were diagnosed with diffuse large B-cell lymphoma [11]. A notable finding was the observation that, akin to patients with solid tumors, those with hematologic malignancies and cachexia or sarcopenia exhibited diminished overall survival and progression-free survival [16]. In our study, the mean survival time was calculated as 10.89 months. The survival curve showed a gradual decline within the first 3 months, reaching approximately 89% at the 3rd month, and remained stable at this level over the following 12 months. Thus, the 6-month survival rate was 89.2%. The mean survival times

for male and female patients were 10.24 months and 10.33 months, respectively. The log-rank test showed no statistically significant difference between the survival curves (p=0.45).

In a subsequent study, Yilmaz et al. [17] assessed the malnutrition risk in 120 patients with hematological malignancies using the NRS2002 criteria and re-evaluated them with the GLIM criteria. Measurements of mid-upper arm circumference, calf circumference, and HG were conducted. The results revealed that low HG (p=0.03), low albumin levels (p=0.001), and elevated C-reactive protein levels (p=0.002) were significantly associated with an increased risk of mortality [17]. In our study, nutritional support provided to the patients resulted in significant improvements in patients' hand-grip strength (p<0.001).

In the study by Staxen et al. [18], which included 61 patients with hematological malignancies, weight loss and loss of muscle mass were detected in 64% and 59% of patients, respectively. Muscle mass was reported to be significantly positively correlated with increasing physical activity level (p=0.003) and negatively correlated with increasing age (p=0.03) [18]. In our study, patients demonstrated a statistically significant increase in both weight and BMI over the follow-up period. The median weight rose from 59 kg (38-88) to 61 kg (42-87) (p=0.001), while BMI increased from 21.75 (15.3-28.4) to 23 (16.8-28.2) (p<0.001).

Tanaka et al. [19] reported a statistically significant decrease in body weight after HSCT in their study of 34 HSCT patients (p<0.001). Additionally, bilateral hand-grip and knee-extensor strengths exhibited significant decreases after HSCT. Furthermore, oral caloric intake and gender (female) were found to be significantly associated with muscle weakness after HSCT (p=0.033 and 0.036, respectively) [19]. Among the women in our study, the MUST score declined significantly, from 4 (2-5) to 2 (0-4) (p=0.007). A comparable reduction was observed in the male patient population, with the MUST score decreasing from 4 (0-6) to 2 (0-5) (p<0.001).

Brotelle et al. [20] retrospectively examined 84 allo-HSCT patients and the mean follow-up period after allo-HSCT was 56.4±47.5 months. The prevalence of malnutrition at the end of follow-up was reported to be 20%. At the end of follow-up hospitalization, the proportion of malnourished patients was significantly higher in the malnourished group than in the well-nourished group (p=0.04). The probability of a statistically significant greater decrease in mid-arm muscle circumference and muscle strength was reported in the malnourished group compared to the well-nourished group (p=0.017; 0.005, respectively) [20]. In our study, measurements of arm muscle strength showed a significant increase, with right arm strength rising from 18.143±9.682 kg to 22.489±9.412 kg (p<0.001) and left arm strength increasing from 17.943±9.557 kg to 22.416±9.277 kg (p<0.001). Additionally, increases in skinfold thickness measurements, which indicate body fat distribution, were observed. Suprailiac skinfold thickness increased from 10 mm (2-22) to 11 mm (7-25) (p<0.001); triceps skinfold thickness increased from 12 mm (3-32) to 14 mm (2-33) (p<0.001); and subscapular skinfold thickness increased from 12 mm (3-25) to 13 mm (6-25) (p=0.002).

Eglseer et al. [21] conducted a retrospective cohort study involving 341 patients who underwent autologuous or Allo-HSCT. They used survival curves and COX proportional hazards models to evaluate whether the risk of malnutrition predicted overall and non-relapse mortality. The survival curves indicated that patients at risk of malnutrition prior to HSCT experienced higher overall and non-relapse mortality during the 1-year follow-up period. Among Allo-HSCT patients, the impact of malnutrition risk on mortality was found to be even more pronounced [21].

Yang et al. [22] conducted a study to determine the prevalence of malnutrition and sarcopenia in 171 Allo-HSCT patients. The prevalence of malnutrition in this patient group was reported to be 24.6% and the prevalence of sarcopenia was reported to be 13.5% [22].

Morishita et al. [23] reported that out of 164 allo-HSCT patients, 83 patients (50.6%) had sarcopenia prior to allo-HSCT. Patients with sarcopenia exhibited reduced muscle strength and increased fatigue in comparison to patients without sarcopenia (p<0.05). Additionally, patients with sarcopenia scored significantly lower in the physical function, bodily pain, and vitality domains of health-related quality of life than those without sarcopenia. Male sex and BMI were identified as significant factors associated with sarcopenia (p<0.01) [23]. Our study demonstrates statistically significant increases in weight, BMI, muscle strength, and skinfold thickness among male patients. In female patients, significant increases were observed in BMI, muscle strength, and certain skinfold thickness measurements; however, the change in weight was not statistically significant.

Study Limitations

The primary limitation of our study is its retrospective design. The small sample size and the study's single-center design constitute additional limitations.

The strengths of our study include addressing the limited available literature on nutritional support for hemato-oncological patients, particularly those undergoing HSCT, and having all patients followed by the same team at a single center. The weaknesses of the study are the relatively small sample size and the inability to assess effects on hospitalization duration and non-relapse mortality. The absence of a control group limits the ability to attribute the observed improvements solely to structured nutritional support. Potential confounding factors such as type of HSCT (autologous vs. allogeneic), underlying hematological diagnosis, chemotherapy intensity, corticosteroid exposure, inflammatory status, and hospitalization duration were not controlled for in the analysis.

The sample size was limited due to the inherent constraints of evaluating HSCT recipients in routine practice. HSCT is performed in a restricted number of eligible patients per center, and retrospective analyses are further affected by missingness of standardized func-tional and anthropometric measurements. In this study, inclusion required availability of paired measurements before and after a structured nutritional support period, which re-duced the number of eligible cases.

Importantly, the pre-post (within-subject) design in-creases efficiency by minimizing between-subject variability, and significant changes were observed even in this modest cohort. Nonetheless, the findings should be interpreted as exploratory and hypothesis-generating, and larger controlled studies are necessary to es-tablish causality and generalizability.

Conclusions

Sarcopenia is defined as the progressive decline in systemic muscle mass accompanied by a reduction in muscle strength or in physical function. In hemato-oncological patients, it may be associated with an increased risk of treatment-related toxicity and higher mortality due to infections. Studies indicate that low muscle mass in patients with hematological malignancies, particularly those undergoing HSCT, may contribute to adverse clinical outcomes. Therefore, the accurate identification of sarcopenia, the assessment of its risk factors and their impact on disease progression, and the implementation of effective treatment strategies are essential. Based on our study, we propose that given its reversible nature, nutritional support may be the most effective approach to managing sarcopenia. Based on our findings, structured nutritional support was associated with improvements in anthropometric parameters and muscle strength in HSCT patients. However, prospec-tive controlled studies are required to determine its comparative effectiveness in the man-agement of sarcopenia.

Ethics

Ethics Committee Approval: Approval for conducting the study was obtained from the İnönü University Faculty of Health Sciences Non-Interventional Clinical Research Ethics Committee (approval no: 2024/6234, date: 16.07.2024).

Informed Consent: Patient data were collected retrospectively.

Footnotes

Authorship Contributions

Concept: M.A.E., E.K., İ.K., B.D., E.H., Desing: A.S., E.K., İ.B., İ.B.Ç., Data Collection or Processing: A.S., M.A.E., İ.B., S.A., B.D., E.H., Analysis or Interpretation: S.A., İ.B.Ç., Literature Search: A.S., M.A.E., E.K., İ.K., B.D., İ.B.Ç., Writing: A.S., İ.K., İ.B., S.A., E.H.

Conflict of Interest: The authors declare that they have no conflict of interest.

Financial Disclosure: The authors have not disclosed any funding.

References

1. Ordonez FB, Zeller Y, Wolleschak D, et al. Low subcutaneous adipose tissue and myosteatosis are prognostic factors after allogeneic hematopoietic stem cell transplantation. Clinical Nutrition ESPEN. 2024;61:274-280.
2. Muscaritoli M, Arends J, Bachmann P, et al. ESPEN practical guideline: clinical nutrition in cancer. Clin Nutr. 2021;40:2898-2913.
3. Bossi P, Delrio P, Mascheroni A, Zanetti M. The spectrum of malnutrition/cachexia/sarcopenia in oncology according to different cancer types and settings: a narrative review. Nutrients. 2021;13:1980.
4. Lopez-Delgado JC, Patel JJ, Stoppe C, McClave SA. Considerations for medical nutrition therapy management of the critically ill patient with hematological malignancies: anarrative review. Nutr Clin Pract. 2024;39:800-814.
5. Pawłowski P, Pawłowska P, Ziętara KJ, Samardakiewicz M. The critical exploration into current evidence behind the role of the nutritional support in adult patients who undergo haematogenic stem cell transplantation. Nutrients. 2023;15:3558.
6. Witham MD, Stott DJ. A new dawn for sarcopenia. Age and Ageing. 2019;48:2-3.
7. Armenian SH, Iukuridze A, Teh JB, et al. Abnormal body composition is a predictor of adverse outcomes after autologous haematopoietic cell transplantation. J Cachexia Sarcopenia Muscle. 2020;11:962-972.
8. Colloca GF, Bellieni A, Di Capua B, et al. Sarcopenia diagnosis and management in hematological malignancies and differences with cachexia and frailty. Cancers (Basel). 2023;15:4600.
9. Baguley BJ, Edbrooke L, Denehy L, Prado CM, Kiss N. A rapid review of nutrition and exercise approaches to managing unintentional weight loss, muscle loss, and malnutrition in cancer. Oncologist. 2025;30:oyae261.
10. Kiss N, Loeliger J, Findlay M, et al. Clinical Oncology Society of Australia: position statement on cancer-related malnutrition and sarcopenia. Nutr Diet. 2020;77:416-425.
11. Tinsley-Vance SM, Mason TM, Komrokji RS. An integrative review of cancer-related cachexia and sarcopenia: a different focus in malignant hematology. Health Sci Rev (Oxf). 2024;13:100205.
12. Poulia KA, Klek S, Doundoulakis I, et al. The two most popular malnutrition screening tools in the light of the new ESPEN consensus definition of the diagnostic criteria for malnutrition. Clin Nutr. 2017;36:1130-1135.
13. Cederholm T, Jensen GL, Correia MITD, et al. GLIM criteria for the diagnosis of malnutrition - a consensus report from the global clinical nutrition community. J Cachexia Sarcopenia Muscle. 2019;10:207-217.
14. Stratton RJ, Hackston A, Longmore D, et al. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. Br J Nutr. 2004;92:799-808.
15. Burkart M, Schieber M, Basu S, et al. Evaluation of the impact of cachexia on clinical outcomes in aggressive lymphoma. Br J Haematol. 2019;186:45-53.
16. Lucijanić M, Huzjan Korunić R, Ivić, M, et al. Psoas muscle index at the time of diagnosis might reflect the prognosis of classical Hodgkin's lymphoma patients. Wien Klin Wochenschr. 2022;134:80-82.
17. Yilmaz M, Atilla FD, Sahin F, Saydam G. The effect of malnutrition on mortality in hospitalized patients with hematologic malignancy. Support Care Cancer. 2020;28:1441-1448.
18. Staxen CS, Andersen SE, Pedersen LM, Poulsen CB, Andersen JR. Nutrition and lifestyle-related factors as predictors of muscle atrophy in hematological cancer patients. Nutrients. 2024;16:283.
19. Tanaka S, Imataki O, Kitaoka A, et al. Clinical impact of sarcopenia and relevance of nutritional intake in patients before and after allogeneic hematopoietic stem cell transplantation. J Cancer Res Clin Oncol. 2017;143:1083-1092.
20. Brotelle T, Lemal R, Cabrespine A, et al. Prevalence of malnutrition in adult patients previously treated with allogeneic hematopoietic stem-cell transplantation. Clin Nutr. 2018;37:739-745.
21. Eglseer D, Bauer S, Huber-Kraßnitzer B, Greinix H. Malnutrition risk prior to hematopoietic stem cell transplantation predicts mortality in adults. Bone Marrow Transplant. 2021;56:2268-2271.
22. Yang P, Song Y, Jing X, et al. Nutritional assessment in early allogenic hematopoietic stem cell transplant patients, a cross-sectional study. Nutr Cancer. 2023;75:1511-1519.
23. Morishita S, Kaida K, Tanaka T, et al. Prevalence of sarcopenia and relevance of body composition, physiological function, fatigue, and health-related quality of life in patients before allogeneic hematopoietic stem cell transplantation. Support Care Cancer. 2012;20:3161-3168.